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Presumpscot River Watershed CD Resource Guide for Teachers, A Product of the Presumpscot River Targeted Watershed Initiative Grant

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**Presumpscot River Watershed
CD Resource Guide for Teachers
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**A Product of the Presumpscot River Targeted
Watershed Initiative Grant**

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Overview

This CD resource guide accompanies a series of maps made available to teachers¹ for educational use. The maps cover basic geographical data within the Presumpscot watershed in southern Maine, including past and present settlement patterns, dam location, population density, surface water quality classifications, and amount of land that has been paved over or built upon (impervious surfaces). Scientists, scholars, conservation experts, land use managers, and the public use such maps to understand resource issues and help make better decisions about them. This CD provides opportunities for students to explore environmental issues in their own watershed using a Geographic Information System (GIS).

Some maps cover the entire watershed, some are focused on specific areas or municipalities, and one covers parts of the larger Gulf of Maine watershed. The objective is to provide a series of resources for students to explore in place-based education. We recommend allowing students time to click around and explore what happens. The Adobe PDF format is very stable and protects the files and the maps from being deleted or edited by the users (see Appendix for information on using the PDFs).

Each set of maps can be used for a series of lessons. Each category is introduced along with key concepts. Next, we provide sample lessons for that category. The first lesson calls for basic skills in locating information and for some critical thinking. Subsequent lessons engage the student in more advanced research and critical thinking exercises. Some lessons can be done in an hour. Some may require more time to collect and apply auxiliary information, but could still be completed in an hour or two depending on the boundaries set for the collection of supporting information. Some of the research questions in the lessons can come from the students themselves. Some research questions can be rather open-ended, as is often the case with environmental research. In such cases, the teacher may choose to expand the lesson into the basis of a unit involving several weeks. Whether the goals are to give the student some initial meaningful contact with spatial data or to develop a long-term, place-based class research project, the maps support active inquiry that lets students explore data layers and look for patterns.

¹ Many of the lessons are designed for middle school students. However, the lessons can be adjusted to serve a wide range of students from grades 3 to 12 and up to first year college.

What is a watershed?

A watershed is a geographic area of land where water and its contents drain to a common place, such as a stream, river, lake, or bay. Watershed boundaries can be ambiguous and subject to interpretation, but are typically delineated using topographic lines to locate the divides where on either side of a high point such as a ridge or hill, water will drain to different water bodies. However, by altering the ways in which water flows through the landscape, human infrastructure such as canals, dams, and stormwater drainage systems can modify watershed boundaries.

John Wesley Powell described a watershed as “that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community.” Powell’s description eloquently conveys the watershed concept while shedding light on the ways in which Maine’s cities and towns emerged from early settlements built around our waterways.

The concept of a watershed is often used by environmental resource managers to convey how human activities on the land affect aquatic ecosystems. Although we often talk about individual watersheds when addressing a specific problem such as non-point source (stormwater) pollution, it is helpful to keep in mind that we all live in a watershed. Watersheds are nested ecological systems, and therefore can serve as useful geographic areas to teach Maine Learning Results Science and Technology standards for Unifying Themes and The Living Environment.

The Lower Presumpscot River Watershed

The Presumpscot River begins at the outlet of the Sebago Lake Dam in Standish. The Sebago Lake Dam divides what was once a continuous system of rivers and lakes² into separate subwatersheds for Sebago Lake and the Presumpscot River. Consequently, the Sebago Lake watershed is usually distinguished from the Presumpscot River watershed, sometimes referred to as the “lower” Presumpscot River watershed. The lower end of Sebago Lake supplies drinking water to much of the greater Portland area. The water flowing out of Sebago Lake and into the Presumpscot River is subject to management of Sebago Lake water levels.

The Presumpscot River is the largest freshwater source to Casco Bay and the two bodies meet at the Presumpscot Estuary. Casco Bay itself is a geographic region within the western Gulf of Maine. Most of Maine drains into the Gulf of Maine. Most of Cumberland County and the Greater Portland Area drain into Casco Bay.

Resource managers use a code system to keep track of watershed and subwatersheds. The hydrologic unit code (HUC)³ for the Presumpscot River watershed is 0106000103.

² Historical topographic maps of the region can be found online at <http://docs.unh.edu/nhtopos/Gray.htm>

³ Information on the HUC system is available online at: <http://water.usgs.gov/GIS/huc.html>

Broken down, the first six numbers (010600) are the basin code (Western Coastal Maine basin), the next two (01) are the sub-basin code (Presumpscot River Casco Bay sub-basin), and the final two (03) are the watershed code (Presumpscot River watershed). A 2-digit code for each sub-watershed within the watershed is appended onto the end of the code.

The Presumpscot River watershed is a complex and interesting system to study in part because its hydrology has been significantly altered by historical and current human infrastructure and uses. The Presumpscot is a good setting to study watersheds as nested systems, as well as to discover the ways in which humans have modified natural hydrology, and the watershed's landscape, over time.

Lesson 1: **Subwatersheds**

The entire portion of the United States east of the Continental Divide can be considered a giant watershed. The entire area west of the Continental Divide is another watershed. The area that drains into the Gulf of Maine is larger than the State of Maine, and is a watershed. Each watershed can contain smaller watersheds which, depending on the area of focus, may be called subwatersheds. You can think of it as a series of bowls in decreasing size nested in each other, where the high points of the bowls are the divides, or high points, of the watershed and the bottom of the smaller bowl drains into the next sized smaller bowl.

The Watersheds HUC map shows Maine's largest subwatersheds within the Gulf of Maine watershed. The nested watershed concept can be explored as you look at the watersheds in Maine and the Casco Bay and Presumpscot River watershed areas. Explore this map to see how watershed areas are divided and decrease in size.

The Presumpscot Watersheds map shows, in more detail, the Presumpscot River watershed and its subwatersheds. In this lesson, using geographical information, explore this map. Some questions to consider:

- What streams and rivers are in each subwatershed?
- How are subwatersheds named?
- How do you determine the boundaries of the subwatersheds?
- How many subwatersheds can you identify?
- Why are subwatershed areas used as management tools?

Lesson 2: **The Hydrologic Unit Code**

- Research the HUC
- Who uses it?
- What part of the country uses it?
- Explain how the code is used.

Census map

The 2000 US Census data used to create this map was adjusted based upon the assumption the most people live within 300 feet of a road, a reasonable assumption for southern Maine. The resultant map probably more accurately reflects the population density than do traditional census maps. The census map shows where people live in the watershed. The map allows students to look at the relation between surface waters and population. Now we do not depend on the rivers for transportation, but many of our communities were built back when rivers were important for transportation as well as sources of power for local manufacturing (saw mills, grist mills). Rivers and watersheds shaped the pattern of landscape development in Maine—a state rich in surface water resources. We continue to use rivers to generate hydropower, to recreate, and to enjoy the outdoors. In addition, rivers provide key ecological functions for numerous plant and animal species, as well as for humans.

This map sorts out urban population density into high, medium, and low (a standard approach, as in Mennis, 2003). But these categories are subjective. How do we decide what is “high”? For this map, the sorting is based in part on what provides meaningful contrast in geographical display of the data. In this case we use *high* as more than 1 person per acre, *medium* as 0.5 to 1 person per acre, and *low* as anything below 0.5 people per acre. This lets students use the map to make comparisons among the population distribution in the watershed.

Students may need to be told that urban areas have populations of 2,500 or more and therefore much of southern and coastal Maine is defined as urban areas. It may be interesting for the students to compare the population density of the United States with that of India (India is about 100 times more densely settled than the U.S.) Having high density is not a “bad” or “good” thing; it is merely a descriptor. For example, urban areas of high density has often been defined as anything over 300 households per acre (definitions of high, medium, and low urban density differ wildly), and low density might be 5 households per acre. Low density could also mean houses are sprawled out inefficiently across the landscape. Yet very high density could mean crowding and pollution. Determining the right density is a function of economic and natural resources as well as the geography of an area.

A good topic for research is the nature of Maine as a rural state with urban areas. What are the benefits and drawbacks about urban areas? For example, cities are better for distribution of resources, but we need the countryside to grow food and to provide habitat. What happens when the urban areas are scattered across the landscape?

After a general discussion about population density, students can explore questions such as:

- Are there more people in a town that has greater amounts of surface water?
- Does population density increase as we get closer to a body of water?
- Are there more people near the big rivers, lakes?
- Why is Portland the most densely settled area?

Students can then move to critical thinking questions such as:

- How can we use our knowledge about urban areas to understand impacts to natural resources and to manage these natural resources?
- What densities are desirable for southern Maine?

Lesson 1: Location, location, location

This lesson allows students to explore population density in relation to surface waters. We start by asking: Where do people live? Do people like to live near water? The class (or small groups) can then work to refine questions such as “Does population increase in proximity to surface waters?” Such questions are open-ended, and call upon the student to form hypotheses about population and water bodies. Then the students use the map to see if the information supports their hypothesis. The results might not be completely clear, but this is often the nature of environmental information. Students can explore what they might need to find a more definite answer. What more information is needed?

A number of issues may suggest themselves as a result of working with the maps. One issue to explore has to do with management: why we’d want to know about the relationship between population and surface water, and what we can do with this information. This is a good opportunity to discuss economic development, community planning goals, resource protection, and roles in managing our surface water resources. For example, water in high density areas may need greater protection in higher density than in more remote areas.

Lesson 2: Planning for growth: population density and geographical information

In this lesson students use the census map to explore relationships between population density and other features of map – such as proximity to streets, dams, land use types. Students can pose questions about relationships between population and environmental conditions. A practical aspect of this lesson is for students to act as community planners. After using the census map, they can make a recommendation about where to put areas for future growth. For further research, students can use other maps to determine what resources are in high density areas. They can formulate ideas about the relationships between population and resources. Students can prepare a report in the form of a recommendation to the town selectboard or planning commission.

Impervious surfaces map

Impervious surfaces include areas that are not grass, forest, or bare ground. Impervious surfaces are concrete or paved areas and the tops of buildings—any surface where water and other surface liquids are prevented from being absorbed into the ground. Sometimes this is desirable, as in the case of gas stations—the area around the pumps must be paved to protect from spills. However, too much impervious surface means that rainwater and snowmelt have no place to go other than downhill. Erosion can be greatly increased from too much impervious surface. Further, the water flowing over the ground can pick up impurities and transport them. Ultimately, following the law of gravity, surface runoff is going to enter our streams and rivers directly by flowing into them or indirectly, by entering groundwater or storm drains. Having pollution enter groundwater can be a real problem if the contaminated groundwater gets into someone's well. Maintaining good drinking water is an important goal.

Ground water aquifers supply over half the population of northern New England with drinking water. Most of these aquifers are extremely susceptible to contamination and they all have groundwater legislation to protect them. State legislation includes groundwater classification systems, ambient groundwater standards, Best Management Practices for potential contamination sources, groundwater discharge permitting, withdrawal permitting, public education, and enabling language for municipalities to manage potential groundwater contamination threats. Title 38, Chapter 3 of the Maine Revised Statutes contains a section addressing groundwater: §465-C. *Standards of classification of ground water*, which designates two standards, GW-A and GW-B. "Class GW-A shall be the highest classification and shall be of such quality that it can be used for public water supplies. These waters shall be free of radioactive matter or any matter that imparts color, turbidity, taste or odor which would impair usage of these waters, other than that occurring from natural phenomena." Class GW-B, is "suitable for all usages other than public water supplies."

Our aquifers occur in two main types: bedrock, and "unconsolidated deposits" of stratified drift or glacial till. Aquifers are recharged by precipitation that percolates through upper layers of the soil profile until it reaches saturated soils. The area that provides the recharge can be determined and mapped. Some communities manage the amounts of impervious surface in these recharge areas. The groundwater also has discharge areas where it surfaces in wetlands, streams, rivers, ponds, and lakes.

Lesson 1: **Location of impervious surfaces**

- Where are impervious surfaces?
- Do they seem greater near surface waters?
- Is there any pattern in their location?
- Are there more impervious surfaces in urban areas?

This map can be linked to the census map, allowing students to see that wherever people live there must be paved areas and as our urban and suburban areas increase, so does storm water runoff and its associated pollution. Students can also compare the impervious surfaces map with the Westbrook aeries.

Lesson 2: **Pavement and water quality**

Relate impervious surface to stream classifications. Impervious surfaces increase runoff, which can enter streams. Students can look at a topographical map to help determine where runoff goes. Does the impervious surfaces map suggest anything about water quality when compare with the stream classifications map?

This map can be a starting point for exploration of how to manage natural resources, subject to population pressures and increased land development. If water quality, for example, is fine in certain areas with a lot of impervious surfaces, then what should be done to ensure the water quality remains high? If there's a decline in water quality, what do students suggest that might change that trend?

As part of this lesson, students can explore these additional questions:

- Is there more runoff in areas that have more people?
- Is there more impervious surface near water bodies? What does that mean for water quality?
- Is there a relationship between hilly areas and pavement?
- Can you tell which areas have steep slopes?
- Are there steep slopes with impervious surfaces?

This lesson can be expanded to include writing reports, conducting community green-up projects, monitoring water quality, and other forms of civic engagement.

Lesson 3: **Impervious surfaces and groundwater**

Some groundwater aquifers are mapped water supplies. Others are potential water supplies that need to be mapped. Some groundwater does not flow into an aquifer but does feed into streams and ponds, and eventually Casco Bay. Relate impervious surface locations to areas where we might want to protect groundwater. Using the internet, can students find the locations of mapped aquifers?

Dams map

This map has the locations of dams on the Presumpscot River and on other bodies of water in the Presumpscot watershed. The Presumpscot has a long history of dams and a fair number of dams for its length. Colonel Westbrook began buying land in the Portland area in 1719. As the King's Agent, he was also responsible for obtaining masts for the British fleet. He built a dam across Presumpscot Falls (in Falmouth) around or shortly before 1734. This blocked the passage of salmon and other fish. Parson Smith noted on July 31, 1734, "an acre of fish, mostly salmon" congregating below this dam (McLellan, 1903: 248). It washed out in 1751 but was rebuilt.

Some information appears with each map as labels for the dams. Many of the dams are owned by a paper company, SAPPI Fine Paper North America (SAPPI), and used to generate power. These are the large dams. SAPPI used to be the S. D. Warren Company, which used the river to float logs to its mills. The dams controlled the water for the log drives. By the 1970s, the log drives in Maine stopped. It was cheaper and faster to ship logs by truck. The rivers benefited from the cessation of the log drives and recovered from the scouring of their banks by the logs, and from the annual depositions of tons of bark. But the dams still remained as sources of hydropower and flood control.

Maine has hundreds of small dams on little streams and ponds, some of them not even inventoried. Hundreds of years ago, people were quite active in making dams to supply water for grist mills, saw mills, and other direct water-to-mechanical-energy systems. In the early 20th century, the larger rivers had dams added to generate electrical power. Many of these newer dams were built at the sites of older dams used for flood control and to power saw, grist, and manufacturing mills.

Lesson 1: Where are the dams?

In this lesson, we use the map to determine the location of dams on the river. Students make a line that represents the length of the Presumpscot to scale, and mark the location of the dams on the line. As part of this task, they can determine how many dams there are per mile. They can also list the other bodies of water on the map that have dams.

Some guiding questions:

- Are dams on lakes or ponds upstream or downstream?
- What does this mean in terms of where fish can go?
- How many dams are in Standish, Windham, Gorham, and Westbrook?
- How many dams do similar rivers in the US and Canada have?
- Is this a highly dammed river in comparison?

Using other maps, students can compare the location of dams with impervious surfaces, population density, and stream classification.

Lesson 2: What are the dams for?

In this lesson, having located the dams, the students determine more about the dams and their meaning. As an open-ended lesson, there is a range of exploration available, depending on the class. For example, in the early grades, students can extract information using the descriptors of each dam, and make tables based on that information. More advanced classes can explore more sophisticated questions or use other maps to provide more detailed answers to the questions.

Sample questions:

- Who owns the dams?
- Who uses the dams?
- Why are the dams located where they are?
- What were they built to do—flood control, power, recreation, fisheries management, shoreline creation?
- Do they still do what they were originally intended to do?
- What are the private benefits?
- What are the public benefits?
- What are the environmental impacts to the watershed from having the dams?

Lesson 3: What about the fish?

This lesson explores the issue of fish passage. First, begin with an explanation of fish and how they use their habitat. Using other sources, students learn what kinds of fish lived in the river hundreds of years ago and then compare them with the fish that live in the water now. They will see that cold water fish such as trout and salmon were there. They will see that salmon are one of the anadromous species that once flourished. Shad were there too, and sturgeon. Now the dams block these fish and make the water suitable primarily for warm water fish such as smallmouth bass. But cold-water fish can still go into warm waters to spawn. Why is the main stem of the Presumpscot now better suited to warm-water fish (why is the water warmer?)? What would it take to restore the fisheries to historic species and levels? In addition to whether or not it can be done, we ask, “Should the fisheries be restored?” Students can take different sides and set up a panel to hear the opposing views. If it is determined that native fisheries should be restored, can this be done through fish passages such as fish ladders, through trucking the fish upstream, or through dam removal? This helps students to see that these are public policy questions concerning public resources and that they can have a say in the answers. Students can also explore fish ecology, to help understand the effects of dams and other river uses on fisheries management.

Some questions related to fish passage:

- Which dam would need to be removed or have fish passage added to allow fish to come from Sebago Lake into the Presumpscot and from Casco Bay into the Presumpscot?
- What routes could provide the most access?

- Which dams have federal licenses?
- Should new canals or accesses be built?
- What information can be gleaned from use of other maps and other resources?
- If some dams are low functioning, should they simply be removed rather than have fish passage added? If so, which ones?
- What dams would have the greatest effects if they broke or were removed – which ones would cause the most flooding and land alteration?

Lesson 4: What about recreation?

Students in this lesson explore how the dams have affected recreation. They can identify the dams that seem to have provided the greatest amount of shoreline for recreation. As part of this activity, they may want to look at topography and natural resources. This will help them to determine the type of recreation that could occur. For example, steep, forested slopes would not be as suitable for beach as would wide, flat areas. Similarly, wide areas of the river corridor are better for some water sports than for others. Students can evaluate and make recommendations on the recreation enhancement roles that various dams in the watershed play.

Westbrook aerals (1940 & 2001)

During World War II, much of the country was flown over and mapped for aerial defense. These photographs were also used to evaluate environmental resources and characteristics such as forest health. Now we have satellite data in addition to aerial photographs. We can use GoogleEarth to locate pretty much anything and anywhere using fairly current aerial photography (<http://earth.google.com/>).

This map set has a scanned copy of a 1940 flyover photograph of Westbrook, and a scanned copy of an aerial photograph from 2001. This is a good opportunity for students to practice making comparisons. The Presumpscot River flows right through the downtown, making it an easy point of reference in using the two aerals. It may take a while to identify the smaller features, but simply comparing the two will give the students interpretive skills. They can explore what buildings existed in 1940 that were still present in 2001. They can look at the street network and the patterns of housing developments.

The canal era occurred from the late 18th century to the middle-to-late 19th century and played a vital role in the growth of the United States. The Cumberland and Oxford Canal and the use of water power shaped the early growth of Westbrook. By 1940, Westbrook was in the era of the train and the automobile, having left the canal era behind. Trains gradually faded from use as a main form of transportation as cars and trucks gained prominence. The aerial photographs help in identifying overall patterns of growth. Geographers and planners recognize three general patterns of commercial development in urban areas: central places, ribbons, and specialized areas. Central places generally consist of central business districts. Ribbons are strips of development formed along well-traveled routes. Specialized areas are perhaps best represented by shopping malls, but also include medical districts, automobile dealer and service areas, and other specialized markets and services. If we know these patterns and how they occur, we have a context in which to understand and predict urban development and change. The environmental and economic successes or failures of all projects in urban areas are influenced by these basic patterns. Roads and other infrastructure services link the patterns; any change to the nature of a pattern will have a potentially greater affect on these services.

Lesson 1: The river corridor

River beds are not static, nor are the corridors that contain the beds. This lesson helps students to think about rivers as dynamic systems. Lots of factors influenced these systems throughout history, and some continue to do so. The Native Americans built wood and stone fishing weirs that affected flow. Logging drives increased channelization, scouring the banks. Dams and canals can change river courses, as can major storm events, earthquakes and other natural events. Bonny Eagle Island was formed in the Saco River after a big storm. An 1865 landslide made a new bed for part of the Presumpscot downstream from Saccarappa. For over 200 years, people have

harnessed the river for power. SAPPI controls the level of Sebago Lake and the Presumpscot River's depth and flow in accordance with a stakeholder plan.

Some questions to investigate:

- Did the Presumpscot change its course?
- If it did, what might have been the cause?
- Did any tributaries of the Presumpscot have their corridors changed?
- Who are the stakeholders that have determined appropriate water levels for Sebago Lake? Use the internet to research your answer.
- What do the dam owners do to control water levels, and how might this affect the river corridor?

Lesson 2: Streets and development

Students can examine and describe patterns of urban development in Westbrook.

Some guiding questions:

- Are there more streets in 2001 than in 1940?
- Is there more development in 2001 than in 1940?
- How does development relate to street patterns?
- Can you tell where commercial and residential areas are?
- How have Westbrook streets changed since 2001? (Use GoogleEarth)

Lesson 3: Urban change and natural resources

In this lesson, students use aerial photographs and resource maps to determine the location of natural resources (including surface waters, parks, mineral & earth deposits).

Some guiding questions:

- Did development change by moving toward or away from water?
- What other natural resources seemed to have changed between the two maps? For example, is there more green space in 2001 than in 1940?
- What kind of green spaces are there—parks, for example, or just undeveloped land? Students can look at ratios of green space to developed space and see if it has changed.

This lesson could be extended into a research project in which students look at the Westbrook town history and documents (including town plans) to see if growth was planned or just the result of market forces. How might the town grow in the future? Or students might find online aerial photographs that allow them to examine change in other towns in the watershed.

Land use map

This map shows the land divided up into general types, based on vegetation and use. Students can discuss the different land use types and what they mean. Students can try to interpret or infer overall patterns of land use and growth.

Another use of the study of land use patterns is to understand the effects of development on streams and surface water quality. The average buffer for an urban stream tends to be less than 100 feet. A complete understanding of existing and proposed residential or commercial development is necessary to determine how to manage the stream and associated buffers. Some proposed developments raise the question of whether or not to add naturally vegetated land use buffers that help protect surface waters. These protective buffers are also based on the uses, functions, and other pressures on the stream and provide the essentials for the stream to maintain its functions. Most urban streams are very small and many are not seen as particularly valuable; their buffers, if they have any, are often only a dozen feet or so in width.

Some regulatory and planning schemes consider streams from the perspective of management zones based on proximity to the water course: stream, middle, and outer. If possible, the stream zone will have at least 25 feet on either side of the stream bank; about the minimum distance needed to actually have a stream rather than a drainage swale or canal. Many cities allow only footpaths, stormwater utilities, and other essential utility services in this inner zone. The middle zone is often another 50-foot width that can include wetlands, floodplain, and steep areas that require protection to keep things from falling into the stream. The outer zone is protected from septic systems, buildings and other large disturbances and is described as “urban greenspace.”

The review of projects for effects on streams should consider urban runoff. Snow storage becomes a problem in stream and river buffer zones in many urban areas because they appear to be a logical place to hold snow cleared from parking lots and other developed areas. Parking lots can have buffers, berms (low, linear mounds), grading (angles of slope), and snow removal schedules—all serving to protect streams. Have students brainstorm to see why snow melt and water runoff from buildings, roads, and parking lots might be a problem for surface waters.

Lesson 1: Patterns of land use

In this lesson, students try to find patterns.

Some guiding questions:

- Can you determine any overall patterns of land use?
- How does the land use relate to surface waters and topography?
- How is current land use different than historical land use?
- What has changed, and why?

- Is there more or less agricultural land use today than there was 100 years ago?
- What has happened to farmland over the last 100 years?

Lesson 2: Making resource decisions

In this lesson, students use the map to make decisions about what resources to use and how to manage them.

Some guiding questions:

- Does it look like there is more open space than developed space?
- How would you use this map to make resource decisions?
- Assume your goals are to promote development while protecting open space and surface waters.
 - What land use categories would you need?
 - Would you need more categories than are on these maps? If so, what are they?
 - What recommendations would you make for people using these maps and categories to make decisions?

Population density map - 1957 & 2000

The data presented on these map layers were developed for the Historical Atlas of Maine Project (<http://www.umaine.edu/canam/cartography/maineatlas.html>). The 1957 data layer was created by tracing densely populated areas from a scanned map image. The 2000 data were created from the 2000 census. Given the subjective nature of the data at the reproduced scale, the data should be used to explore general trends and patterns of development in the watershed. Students may wish to compare the data on these map layers with other maps as part of explaining patterns of density and making predictions about the future.

Lesson 1: **Patterns**

Students can explore the population density maps and compare them.

Some guiding questions:

- Are there any patterns of development noticeable in 1957?
- Are there any patterns of development noticeable in 2000?
- Do these patterns, or lack of patterns, seem to relate to the location of surface waters?

Lesson 2: **Predicting growth**

Based on what you determine from changes in 1957 and 2000 and other map data, what density would you predict for 2020? If in doubt about other factors, assume other factors will remain the same and population will increase 50%. Students can discuss the basis for these assumptions and research if these assumptions should be changed.

Stream classifications map

The data set for this map labels water classifications for surface waters in the Presumpscot watershed. Some minor bodies of waters may not have been classified yet; the federal Clean Water Act enables each State to set up its own water classification scheme. Maine classifies surface water resources as AA, A, B, or C. This classification does not necessarily tell how to manage water resources, nor how to review potential impacts for all environmental events that could affect surface waters. What it does do is provide public acknowledgement of how the rivers and streams are identified in terms of water quality. These classes affect state permit processes and are used in local and state planning.

General Water Quality Classification:

- Class AA: Scenic or otherwise significant natural resources and Class A quality water.
- Class A: Suitable for public water supply, but may need some filtering; Class A waters allow impoundments and very restricted discharges, so the risk of degradation exists.
- Class B: Suitable for swimming, recreation, irrigation, habitat, aesthetics, water supply if filtered and disinfected.
- Class C: Suitable for recreational boating, irrigation of crops that will be cooked before being eaten, wildlife and fish habitat, industrial uses.

When planners review proposed projects, they have a list of criteria they are allowed to use under the law. These criteria generally fit into one of four categories. The four most common categories of development impacts to surface waters are:

- Aesthetics
- land use (past, present, and future)
- water supply
- water pollution.

Development review often centers on these four categories because they can address most uses and values of surface waters, along with potential impacts.

Lesson 1: Is the water quality better closer to the ocean?

Water can get cleaner as it goes through rapids, natural filtration in the ground, subsurface treatment systems, and municipal treatment plants. Many of the impurities in Maine waters come from agricultural runoff, so when water leaves farm country and enters the coastal urban area, its quality might actually improve. Water can also pick up impurities as it flows down to the sea. Thus, water is already contaminated when it gets

close to Casco Bay or other coastal bodies. What is the case for the Presumpscot and its tributaries? Students can make hypotheses and use the maps to test them.

Lesson 2: **Determining “good” water quality**

Using the map, take a position on whether or not the watershed has good quality water. Water quality classifications are related to use. Some people think these classifications are too arbitrary. Whether or not a use is appropriate is a public policy and management concern. Students can discover who makes the classification assignments in Maine, and learn about the process used for classification decisions. Research use of the water and determine whether or not the classifications are appropriate. What kinds of changes would you make? Estimate the water quality for any bodies of water that do not already have their water quality indicated. For a particular river, pond, or stream, students can determine how the water is downgraded or upgraded to receive a new classification.

Historical atlas

This set of maps is from the Beers' 1871 *Atlas of Cumberland County*. It was the first comprehensive atlas of the watershed that showed individual households and businesses. F. W. Beers and company went all over the United States making county atlases.

Early maps do not show much detail of the Presumpscot watershed. A 1771 map shows the general route of the river (Figure 1). Students can view the map online.

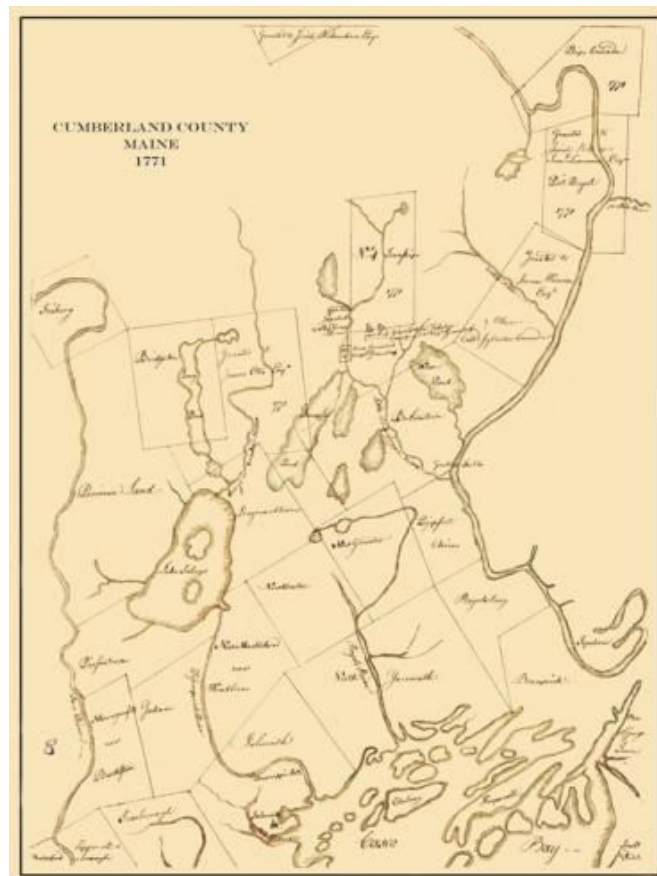


Figure 1. 1771 Map of Cumberland County drawn by P.S. Longfellow
(Available online at various sources, including Maps of the Past, Inc.
<http://www.historicmapsrestored.com/>)

Townships in the District of Maine (Maine was a part of Massachusetts and did not become a state until 1820) had to provide a survey that showed town boundaries, industrial sites, public routes and ways, and meeting house locations. P. Stephen Longfellow, grandfather of the poet Henry Wadsworth Longfellow, undertook the Gorham survey in 1794, identifying the location of a saw mill and bridge at Little Falls on the Presumpscot, and five mills on the Little River, which feeds into the Presumpscot less than a mile below Little Falls. Two of the mills were near what is now Route 114 on the Little River, and blocked the flow of fish upstream to the nearby Wabanaki Indian

village only half a mile away. None too pleased, the Native Americans burned down the original 1743 sawmill and gristmill in 1745 shortly before the hostilities led to the Gorham settlers to move into the Fort Hill fort. It was the only gristmill in Gorham, and its loss was quite an inconvenience.

Settlers worked their way up the river, adding sawmills. A sawmill was built at Saccarappa Falls in 1739. Shortly after the 1730's sawmills were operating in what is now Westbrook, sawmills were built at Mallison Falls and on the Little River (1743). By the middle of the 18th century, mills were on the Presumpscot River wherever there were falls (see Lesson 1, in which students locate sawmills).

Transportation in the 18th century consisted of use of rivers and their tributaries, and dirt roads. Most roads were not in good shape and it took quite a while to get anywhere on horseback.

In addition to showing the river, Beer's Atlas of 1871 shows the canal route that roughly parallels the Presumpscot River on the west side until it reaches Westbrook, where it heads overland to Stroudwater. In 1859, reporter Robert Jordan Dingley of *The Bridgton Reporter* wrote about his trip on the canal in an article entitled "Five days behind the mast: or life on the canal boat." The entire article, originally published September 15, 1859, is presented on Darrien McLellan's web site (<http://home.maine.rr.com/alewifecove/maps.htm>). Students can read the diary-like entries to get a sense of what a trip on a canal boat would have been like. An excerpt is quoted below, describing the end of a round trip on the Cumberland and Oxford Canal:

Friday, September 2nd [1859]

Cloudy and lowery. Leave "Kemps" [north of Gambo] at 5 o'clock a.m. and after passing through 6 locks and meeting one boat we arrive at Great Falls, Gorham, at 7 o'clock. Great Falls is quite an extensive as well as a pleasant village; the Presumpscot furnishes a strong water power which seems to be well improved, but as the boat did not stop I had no time to note anything in particular, with the exception of a country store, and a millinery shop nearby.

Go through four locks and pass a small village containing a sawmill and a few dwellings - meet another boat- pass through another lock. Weather more pleasant. We pass through two locks and are at the head of the Canal. Distance from Portland - twenty miles.

Lesson 1: Sawmills

In this lesson, students gain practice in interpreting information from historical maps. Students can read the 1871 map to see where sawmills were located. In the 18th century, the Presumpscot had 17 falls. They can also add the layer that shows some of the earliest mills built—many were there over 130 years before the 1871 map.

Guiding questions:

- Can you find the Gorham sawmill and gristmill that were burned in 1745?
- Where were sawmills located on the Presumpscot and its tributaries?
- Can you identify where any of the falls were located?
- When do they think the first sawmills were built?
- What conditions would you want to have if you were building a sawmill?
Students can brainstorm responses. A good discussion would bring out some of the following points.
 - The settlers would need a source of water to power the sawmill and the best place for this is where the water drops fast.
 - The mill should be close to the forest. In the 18th century, much of this area was forested—there were lots of trees everywhere (but by the late 19th century almost all of the forest was completely gone; now we have much more forest than we did a hundred years ago).
 - Sawyers would also want a place where they could float logs down to the mill and store them there in a holding pond.
 - Since some of the wood might be transported by wagon, they would need to be near a road.
 - Since it took time and money to move wood, they would want to be near a market or village.

Lesson 2: Place identification

The Beer's Atlas of 1871 lists the names of individual householders. Looking at modern maps, we can see that the names of streets and communities sometimes reflect the same names of people who lived in the area in past centuries. Students will also note that only the male head of household is given on the atlas. If there is no male head, the person might be listed as Mrs. Henry Swift, Mrs. Swift, or Mrs. H. Swift—her first name will not be given. Ask the students why they think this was done. Students can research modern street and community place names that seem to be the last names of people. Looking at the Beers atlas, they can look for names of family households or businesses that match with present-day names.

The development of trade and settlement led to an increase in community identity. As villages grew into towns, place names changed, reflecting an increase in government and shifts in commerce. Sometimes old maps show different place names than what we have now. For example, Great Falls is now known as North Gorham. Windham was once called New Marblehead. Mallison Falls was once known as Horse Beef Falls, and the surrounding community was known as Horse Beef. The story dates to the late 18th century, when a miller found a cask of beef that contained a horseshoe. Another version

of the story is that a wagon wheel was lost on a wagon carrying a shipment of beef for the militia when a barrel tumbled out of the wagon and broke on the bridge, revealing a horseshoe among the supposed beef.

Lesson 3: Native American settlements before the Revolutionary War

What was the Presumpscot River valley and watershed like before the Revolutionary War? There were quite a number of Native American villages—and they had cleared many fields for agriculture long before European settlers came. The French and Indian War (1754 – 1763) was but the latest in a long string of conflicts between European colonial powers that involved Native Americans on both sides. Associated skirmishes between settlers and Native Americans occurred throughout Maine. Another source of conflict was competition, primarily for agricultural land, forest resources, and food. Students can imagine what the watershed looked like before dams, before the canal, and when only a few hundred people lived in it. Where would be good areas to trap game? Where might Native Americans build fishing weirs? Assume there were 10 Native American villages of about 10 families in the watershed in the year 1600. Students can determine where to place these villages so that the inhabitants have access to water, to other resources, and to each other for trade. The village sites should be spread out to maximize resource use and reduce competition between villages. They also want to be safe from enemies. A variety of maps and resources could be used in exploring these and other questions.

Lesson 4: Canal boat trip

Students can imagine what it is like to be on a canal boat trip in the late 19th century. What would they pack in their suitcase for a two-day trip? If they were in business, what places would they access to the canal? Railroads were serious competition to the canal, which would soon be abandoned, so the canal company had to work hard to haul goods that were not so efficient for the railroads. Using the Beer's Atlas of 1871, determine where the boat could stop if it was picking up:

- lumber from saw mills
- gunpowder
- canned corn (Maine was the first in the nation to produce canned sweet corn.)
- wool and other fabric

Where to go for more information

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Contact Information

Future inquiries regarding this guide and the maps may be addressed to Sarah Plummer, Education Coordinator at the Cumberland County Soil & Water Conservation District at sarah-plummer@cumberlandswcd.org or (207) 892-4700 x 107. We invite feedback on the maps, guide, and lessons. Please send comments on the lesson plans you have used and additional ones you have developed, as we plan on updating the guide and sharing successful applications with others. Additional CDs may be available.

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Sanford, R., S. Plummer, R. Mosher, and M. Craig. 2009. Presumpscot River Watershed CD Resource Guide for Teachers. Casco Bay Estuary Partnership, Cumberland County Soil and Water Conservation District, Windham, Maine.

Appendix 1 - Using Adobe Reader® to View Maps

Adobe Reader® is the tool for opening and using Adobe PDFs. It is available for free download at www.adobe.com/products/reader/.

Although you can't create PDFs, or save changes in Reader, you can use it to view, print and find information. After opening a PDF, you have a variety of tools to help you find information quickly.

Viewing Maps in Adobe Reader®

To open a map file, use the File>Open in Reader. Alternately, you can locate and double-click the pdf file in My Documents to open Adobe Reader® and the selected document.

The **Layers** feature in Reader allows you to view a list of map layers and to turn map layers on and off.



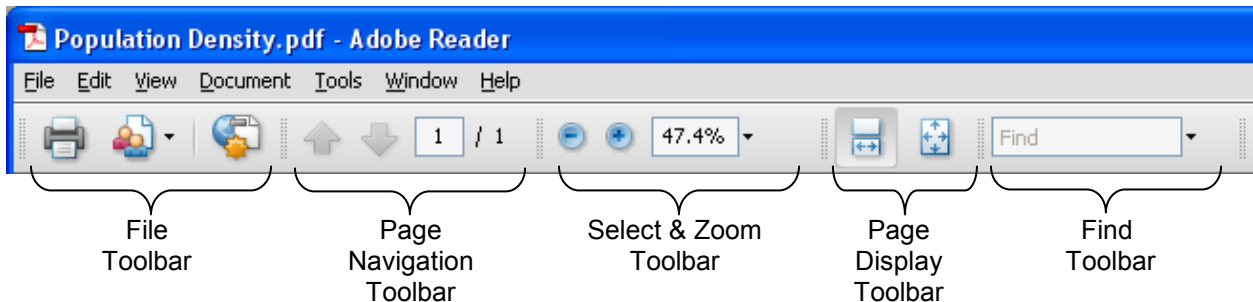
Click the Layers icon on the left side of the Reader window to open/close the layer display area.



The Eye icon next to a layer indicates that the layer is visible. Click the icon box to turn layers on/off.

Adobe Reader tools and toolbars

Five *Adobe Reader* toolbars open by default:



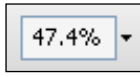
Select and Zoom Toolbar



Click to zoom out by a pre-set amount



Click to zoom in by a pre-set amount



Type in a magnification percentage, or click the menu and select a preset magnification.

Page Display Toolbar



Click to set the magnification so that the PDF fills the document window



Click to display the entire map page in the window

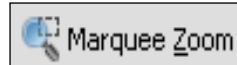
Tools Menu

Options on the Tools menu (Tools > Select & Zoom) give you more ways to adjust the page for better viewing.



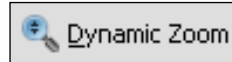
Hand Tool

The Hand Tool moves the map without changing the magnification. Click and drag to use the tool.



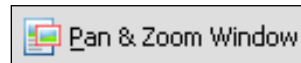
Marquee Zoom

The Marquee Zoom tool works in a few different ways. Use it to drag a rectangle around an area you want to fill the viewing window. Click the map using the Marquee Zoom tool to zoom in one preset level, centering on the point clicked. To zoom out by a preset level, Ctrl-click the Marquee Zoom tool.



Dynamic Zoom

The Dynamic Zoom tool zooms in when you drag it up the page, and out when you drag down. It also works with the mouse wheel: roll up to zoom in, roll back to zoom out.



Pan & Zoom Window

The Pan & Zoom Window tool adjusts the magnification and position of the view area to match the area in an adjustable rectangle in a thumbnail view of the page.



Loupe Tool

The Loupe Tool displays a magnified portion of the PDF that matches the area in an adjustable rectangle on the document page.

Appendix 2 - CD Table of Contents

All map images on this CD are optimized for viewing. They are designed to be printed on an 18" x 24" sheet. To print the images a different size page, use the option to scale printing to the page size of the printer. Alternately, most printers/computers have an option to tile the map to multiple pages. You can print the image in multiple pages and tape the pages together.

CD Contents:

Presumpscot River Watershed Resource Guide.doc – Resource guide in Word document format

Presumpscot River Watershed Resource Guide.pdf - . Resource guide in Adobe PDF format

Beers Atlas Pages (folder) – This folder contains 27 page of images from the 1871 Cumberland County Atlas for areas within the Presumpscot River watershed.

PDF Map Files –When opened with Adobe Reader®, the map layers used to create these maps can be clicked on/off for viewing (See Appendix 1). There is one .pdf file for each map section in the Resource Guide.

Census.pdf – Census map

Dams.pdf – Dams map

Historical Atlas.pdf – Historical Atlas images

Impervious Surfaces.pdf – Impervious surfaces map

Land Use.pdf – Land use map

Population Density.pdf – Population density 1957 & 2000 map

Stream Classifications.pdf – Stream classifications map

Westbrook Aerials – Westbrook aerials (1940 & 2001) images

Appendix 3 – Map Notes and Layer List

Population density map – 1957 & 2000

The data from this map was originally created for the Historical Atlas of Maine Project (<http://www.umaine.edu/canam/cartography/maineatlas.html>) in an effort to explore landscape changes that have taken place with the spread of the automobile. The 1957 data was created by interpreting density from 1957 USGS maps. Areas that showed clusters of houses were considered developed. For 2000, data was created using 2000 GIS census data, following the assumption that most people live near a road, and that areas with a population density of 2 or more people per acre are developed. This makes the definition of 'developed' subjective, but the overall patterns and general trends are worth exploring. Also note that the density layers on this map extend across most of the watershed, but some areas, to the north and west, are missing. Absence of data in these areas does not mean that the areas are undeveloped – only that the data was not created and added to the map.

Metadata for map layers:

GIS Data were created and processed using ArcMap from Environmental Systems Research Institute (ESRI). Data obtained from the Maine Office of GIS (MEGIS) downloaded from <http://megis.maine.gov/>. Unless otherwise noted, data processing was by Orbis Mapping Solutions (Orbis).

1/4 Mile Grid – The 1/4 mile grid covers Westbrook with locator letters along the side, and numbers along the top. The primary purpose of this layer is to facilitate discussion.

1/2 Mile Grid – The 1/2 mile grid covers Gorham with locator letters along the side, and numbers along the top. The primary purpose of this layer is to facilitate discussion.

1 Mile Grid – The 1-mile grid covers Westbrook with locator letters along the side, and numbers along the top. The primary purpose of this layer is to facilitate discussion.

5 Mile Grid – The 5-mile grid covers Presumpscot River Watershed with locator letters along the side, and numbers along the top. The primary purpose of this layer is to facilitate discussion.

50 Foot Resource Buffer – A 50 foot buffer created around Surface Water. Source: MEGIS.

100 Foot Resource Buffer – A 100 foot buffer created around Surface Water .

1871 Beers Atlas (Westbrook and Gorham) – Scanned and geo-referenced images from the 1871 Cumberland County Beers Atlas. The 1871 images were positioned as closely as possible to real-world location, but keep in mind that all maps have inaccuracies, and the inaccuracies become particularly clear when superimposed

with aerial photographs. Because inaccuracies exist, especially at the scale of mapping used, the maps should not be used to pinpoint structure sites; the precise locations of 18th century buildings and sites may not be located exactly as shown on the map (and on the superimposed aerial photograph).

1940 Aerial Photographs – Scanned copies of images obtained courtesy of USDA, Natural Resources Conservation Service, Scarborough Field Office. Photo Source: War Department, Headquarters of the Army Air Forces, Photographed 6-3-40. Classification changed to Unclassified by Authorization Directorate of Intelligence, USAF, Aug. 1957. Soil Conservation Survey #ME-SCD-9. Scanning and geo-referencing: Orbis.

2001 Aerial Photographs – Images from ORTHOHF. From April 2001. Source: MEGIS.

Dams and Dams Info – Subset from IMPOUNDS. The Dams data layer shows the location of the dams in the Presumpscot River watershed. Data is from a 1987 survey by the U.S. Army Corps of Engineers. Additional points were added by Maine Department of Environmental Protection and Bureau of Land and Water Quality. In 2004, the Maine Emergency Management Agency reviewed and updated point locations. Source: MEGIS

Developed by 1957 – This layer is an interpretation of a 1957 USGS topographic map. The interpretation was somewhat subjective – areas that had clusters of buildings were classified as “developed.” Source: Orbis.

Developed by 2000 – This layer was created from Population Density by extracting areas where the density is greater than, or equal to 1 person per acre. Data Source: MEGIS.

Historic Sites and Site Labels – Data layer created from a variety of historical literature and maps.

Impervious Surfaces – Subset of IMPERV. Source: MEGIS. This data set derived from 5 meter SPOT imagery collected in the summer of 2004 over the State of Maine. It is part of a larger mapping initiative by the State of Maine to quantify land cover. Areas of imperviousness are characterized by anthropogenic features such as buildings, roads, parking lots, etc.

Land Use Layers – (Forest, Open Land, Water, Wetland, Farmland, Developed, Estuary/Tidal) from MELCD. The data are primarily derived from satellite imagery from 1999-2001. This imagery constitutes the basis for the National Land Cover Dataset (NLCD 2001) and the NOAA Coastal Change Analysis Program (C-CAP). The data were further refined by the State of Maine requirements using SPOT 5 panchromatic imagery from 2004. For this project, the 27 classifications used in MELCD were simplified into the 7 listed. Source: MEGIS.

Presumpscot Watershed Outline – Data is a sub-set of WBDME6_A. Data Source: MEGIS.

Population Density – Geographic data from US Census blocks, BLKS00. Population Data from BLKS00SF1. Census data, often mapped using census blocks, is

displayed on this map using the assumption that most people live within 300 feet of a road. In rural areas, population depicted in the conventional way, using census blocks, attributes a small number of people living on large tracts of land. In reality, much of the development is clustered near roads, with large open spaces back from and between roads. This methodology attempts to better reflect the reality of the region's population density. Census data is for 2000.

Created by buffering roads (see below) by 300 feet, clipping census blocks using roads, and calculating density based on acreage of area within road buffer. Data Source: MEGIS.

Roads and Road Names – From E911RDS for all towns except South Portland, from MEDOTPUB. Data Source: MEGIS.

Stream Classifications – Data layer with streams and rivers colored to depict water quality classifications. Water quality classifications from WQRIVERS and WQSTREAMS. Data Source: MEGIS.

Sub-Watershed Outlines and Watershed Names – Data is a sub-set of WBDME6_A. Data modified to provide more detail and to include several small local watersheds not included in data. Only the sub-watersheds in the Presumpscot River watershed are labeled. Data Source: MEGIS. Processing: Cumberland County Soil and Water Conservation District and Orbis.

Townlines – From METWP34L. Data Source: MEGIS.

Town Names – From METWP24P. Data Source: MEGIS.

Surface Water and Water Body Names – Combined layer of lakes, rivers, and streams. Data Source: MEGIS.

Lakes – from WQPONDS (MEGIS)

Rivers – from WQRIVERS (MEGIS)

Streams – from WQSTREAMS (MEGIS)

Topography – Raster elevation model created from USGS contour lines, CONTOURS. Data Source: MEGIS.